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ANALYSIS OF U.S. NAVY AIRCRAFT
ACCIDENT RATES IN MAJOR AVIATION COMMANDS

by

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Analysis of U.S. Navy Aircraft
Accident Rates in Major Aviation Commands

by

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ABSTRACT

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I. INTRODUCTION

Aviation safety is one of the major tools used to obtain a Navy goal of fleet readiness. The reports necessary to provide the Naval Safety Center with a means by which to judge the Navy's progress in aviation safety are delineated in OPNAVINST 3750.6 (Series). Through analysis of reported mishaps, the safety center has the ability to determine correctable material and personnel deficiencies. Through the administrative effort expended in submitting reports, the Navy can be repaid many times in the savings of lives and material.

Due to extensive post aircraft accident analysis by accident investigation teams, aircraft accidents have been broadly categorized in terms of causal factors. Causal factors are not to be confused with environmental factors but are any event, act, failure/malfunction, circumstance or occurrence, the presence or absence of which caused the accident. Contributing to accidents are poorly designed equipment, supervisory error, improper aircrew training, failure of a facility to provide adequate runway drainage, maintenance induced equipment malfunctions, etc.

An accident is designated as a major accident if: (1) loss of life occurs; (2) complete loss of an aircraft is involved; or (3) substantial damage occurs to any

aircraft involved where substantial damage is defined in Appendix A of OPNAVINST 3750.6 (Series). The most common cause cited in the literature on aircraft accidents is pilot error. In a study by Brictson, et al. [1969], approximately seventy-eight percent of the accidents studied attributed pilot error as being the primary causal factor, with only eight percent being attributed to support personnel errors, and the remaining thirteen percent being attributed to aircraft failure, equipment failure and/or weather.

A study conducted for the Royal Air Force by Goorney [1965], concluded that fatigue, personal worries, complacency, emotional stress and lack of current flying experience, directly contributed to pilot error. Goorney's study states that excessive ground duties prior to flying attributed to fatigue and that personal worries concerning marriages, dating, housing, financial and work problems attributed to emotional stress.

Collicot, et al. [1972] categorized accident causal factors into pilot error, material failure, maintenance error, and miscellaneous other causes. The authors compared Air Force F-4 accidents with Navy-Marine F-4 accidents and attributed maintenance error disparities to the fact that Air Force F-4 aircraft only realized one-tenth of the cannibalization of parts that Navy-Marine aircraft realized. The authors also singled out that the Navy-Marine officer job rotational policies resulted in lower in-type flight

hours for Navy-Marine aviators and thus adversely affected their pilot proficiency. The authors also noted that, in comparing dual piloted to single piloted aircraft, the dual piloted aircraft had fewer accidents per ten thousand hours than the single piloted aircraft. The authors conclusion was that pilot mental overload was critical in the determination of a prime factor in pilot error.

As a result of the Collicot study and a study by Kowalsky, et al. [1974], the emphasis that pilot induced accidents were caused by lack of pilot proficiency was shifted to implications that pilot error accidents may be attributed to a state of temporary mental overload where the pilots incorrectly evaluated information inputed to them during the overload period.

Since the advent of the Naval Safety Center, a great deal of effort has been expended in maintaining extensive data banks of accident related information. Statistical Analysis of available data should enable predictive mathematical models to be constructed, as much of the data available can be construed as measures of pilot proficiency. Myers [1974] attempted such a statistical analysis, hypothesizing that measures of pilot proficiency and experience would suffice to form an adequate foundation for accident rate analysis. He applied statistical techniques of principle component analysis and cluster analysis to ten variables obtained from the Individual Flight Activity Reporting System (IFARS) which are submitted to the Safety Center. Comparing two groups of

pilots--one group being involved in aircraft accidents and the other group being accident free--his results were not as pronounced as desired. The fact that each group contained only fifty subjects is reason to believe that this small sample size suppressed his accident predictive results.

Maxwell and Stucki [1975] applied regression analysis techniques to an all Navy study of aircraft accidents for the period July 1968 to June 1974. Their analysis indicated that 46.6% of the total accident rate variability is explained by pilot related variable measures if one wishes to accept a statistical confidence level of 75% as meaningful. Results of their study corroborated with the previous studies cited, that pilot error of one sort or another is the single largest cause of aircraft accidents.

The author of this writing agrees with Maxwell and Stucki that sufficient data should be currently available, from which predictive capability is extractable. The variable nature of the monthly accident rate suggests underlying factors, causal and thus definable in their role of accident perpetration. Using statistical analysis to isolate variable measures associated with pilot proficiency and aircraft maintenance which vary either directly or indirectly with accident rate, then predictive and thus preventive knowledge can assist in lowering the loss of human life and the dollar loss resulting from aircraft accidents.

II. PROBLEM DEFINITION

The Naval Safety Center (NSC), Norfolk, Virginia, has provided the author with major accident rates computed for aircraft accidents for eight major commands: (1) Commander Naval Air Forces Atlantic (COMNAVAIRLANT); (2) Fleet Marine Forces Atlantic (MARLANT); (3) Commander Naval Air Forces Pacific (COMNAVAIRPAC); (4) Fleet Marine Forces Pacific (MARPAC); (5) Commander Naval Air Training Command (CNATRA); (6) Commander Marine Training Command (MARTC); (7) Naval Reserves; (8) Commander Research Development Test and Evaluation/Naval Air Systems Command (RDT&E/NASC); for fiscal years 1969 through 1974. The accident rate is defined as the total number of accidents in a given month multiplied by a constant factor of ten thousand and then divided by the total monthly hours flown for a given command. Major accidents by definition, as delineated in OPNAVINST 3750.6 (Series), are characterized by loss of life, loss of aircraft, or extensive aircraft damage measured in necessary man-hours to effect repair.

A variety of approaches to look for consistent trends or cyclic phenomena in aircraft accident rate of Navy-Marine accidents was undertaken by Poock [1976]. None were found that could pass any statistical tests to verify their existence beyond reasonable elements of chance.

The purpose of this paper is to further explore accident rate dependence on time related variable measures for the eight major commands listed above in hopes that one or more of these measures can be identified for later use in the reduction of accident rates and thus the reduction in the loss of lives and money.

III. ANALYTICAL PROCEDURES

A. DATA SOURCE

OPNAVINST 3750.6 (Series) promulgates the requirements and procedures for the reporting of each aircraft accident or incident involving all Navy and Marine aircraft. This establishes control over accident data with the goal of increasing aviation safety. The reports are forwarded to the Naval Safety Center (NSC) for inclusion in their master data bank. Accident data currently available from NSC can provide approximately eighty variable measures for each accident.

B. DATA SELECTION

The NSC data bank provides a ready source of data for each accident or data set. However, as this is a continuation of the work of Maxwell and Stucki, the 2110 computer data cards obtained from NSC for their study were also used in this study.

The initial step in the conduct of the current accident rate analysis was to select appropriate variable measures or data points. A data point for an accident was considered to be any suitable variable measure associated with the accident and a data set consisted of data points for a

specific accident. Specific measures were chosen in mutual discussions with NSC personnel.

Selection of appropriate data points required that each point be time dependent. Data point time dependency and subsequent selection was based on the variable descriptions contained in the Manual of Code Classification for Navy Aircraft Accident, Incident and Ground Accident Reporting (Code Manual) promulgated by NSC.

A sufficient number of data sets had to be incorporated into the analysis to facilitate viable statistical results, but the span of time defined by the data sets had to be chosen with care. Unfortunately, of the six fiscal years of data available to the author, only fiscal years 1972, 1973, and 1974 were used in this study. Fiscal years 1969, 1970, and 1971 were eliminated primarily because some data sets were either incomplete or entirely void of information. A change in reporting procedures during 1972 alleviated this problem. Also, in the fiscal years chosen for the analysis, a particular accident too often had to be disregarded due to incomplete data or to the fact that the particular occurrence involved another aircraft and the other aircraft was deemed at fault. Therefore, either due to insufficient data or to an occurrence and not an accident, a total of 636 of the original 2110 data sets available were used. Data for each variable of these 636 data sets were complete and there is absolutely no data missing in the data sets used in the analysis.

Ten data points from each set of the original thirty data points requested by Maxwell and Stucki were selected for inclusion in the current analysis. Nine of these data points are the same data points used in the Maxwell and Stucki study with the addition of the data point "Years Experience as a Designated Naval Aviation" and the data point "Flight Purpose Code" deleted. In addition, the data points selected also allowed the author to construct four additional variables deemed as measures of experience and pilot proficiency. Table I lists the basic variables used in the study. The first ten variables listed are from the Naval Safety Center and variables eleven through fourteen are the constructed variables.

Pilot age, years experience as a designated Naval aviator, experience, age at designation as a Naval aviator and total flight time in the aircraft involved in the reported accident have been considered as measures of pilot experience. If these variables are true measures of experience they should exhibit negative correlation with accident rate, assuming a relationship exists.

There is the age old adage of "practice makes perfect" which this author construes as a measure of pilot proficiency. Included in the category of pilot proficiency were total flight time during the preceding ninety days, total night flight time during the preceding ninety nights, total day flight time during the preceding ninety days, the number of carrier landings in the last thirty days, the number of carrier landings in the last thirty nights, and the ratio

TABLE I

DATA SET INCLUDED IN CURRENT STUDY

1. Accident rate by month (RATE)
2. Pilot's age (AGE)
3. Years experience as a designated Naval aviator (DNA)
4. Total flight time in accident involved aircraft model (TTIME)
5. Total flight time during preceding ninety days (TOT90)
6. Total night flight time during preceding ninety nights (NITE90)
7. Daylight carrier landings during preceding thirty days (CLDAY)
8. Night carrier landings during preceding thirty nights (CLNIT)
9. Number of aircraft tours (ACTOUR)
10. Aircraft flight hours since last major or minor inspection (ACHRS)
11. The ratio of years experience as a designated Naval aviator and total flight time in the accident involved aircraft model (EXPER=DNA/TTIME)
12. Age at designation as a Naval aviator (WINGS=AGE-DNA)
13. Total flight time during preceding ninety days minus total night flight time during preceding ninety nights (DAY90=TOT90-NITE90)
14. The ratio of total night flight time during the preceding ninety nights to total day flight time during the preceding ninety days (NITEDAY=NITE90/DAY90)

of night flight time to day flight time during the preceding ninety days and nights.

To measure airframe age and general condition, two variables were selected. All Navy/Marine aircraft are required to undergo a Periodic Aircraft Rework (PAR) cycle for analysis and repair after having accumulated a specific number of flight hours. Thus, the number of aircraft tours was chosen as one variable. As a measure of aircraft condition, the aircraft flight hours since the last major or minor inspection was also selected as a variable.

C. PRELIMINARY DATA PREPARATION

A common theoretical proposition in parametric statistics states that changes in one variable can be explained by reference to changes in several other variables. Such a relationship is described in a simple way by a multiple linear regression equation as described in Appendix C. To use this statistical method the relationships between the variables require the following assumptions: (1) normality; (2) data must be in the interval measurement scale; (3) the number of observations exceeds the number of coefficients to be estimated; and (4) no exact linear relationships exist between any of the explanatory variables. Normality was assumed by invoking the Central Limit Theorem and the technique of averaging by month was used to transform the data into interval data.

Raw data for each of the first ten variables of Table I was averaged by month for each of the thirty-six months within the time span selected and was also used to compute the values for the remaining variables of Table I.

D. THE ANALYSIS TECHNIQUE

To conduct the statistical analysis of the data set the author selected the forward (stepwise) multiple regression computer program package developed by Jae-On Kim and Frank J. Kahout at the University of Iowa. The program is included in the Statistical Package for the Social Sciences (SPSS) compiled and edited by Nie, et al. [1975].

Multiple regression may be viewed as a descriptive tool whereby the linear dependence of one variable on other variables is summarized and decomposed. Kim and Kahout state that the most important uses of the technique as a descriptive tool are:

> (1) to find the best linear prediction equation and evaluate its prediction accuracy; (2) to control for other confounding factors in order to evaluate the contribution of a specific variable or set of variables; and (3) to find structural relations and provide explanations for seemingly complex multivariate relationships, such as is done in path analysis.

However, the primary purpose is to evaluate and measure overall dependence of a specified (dependent) variable on a set of other variables (independent). The dependent variable used for the current study was accident rate and the independent variables consisted of those variables listed as 2 through 14 in Table I and all the variables listed in Table II.

To explain the variables listed in Table II it must again be stated that regression analysis assumes the underlying relationships among the variables are linear and additive. There are many occasions for which such simple linear models are inadequate. Early efforts by the author dealt entirely with first order variables but examination of scatterplots of the residuals, which are conceived as measures of the error component, indicated lack of linearity and the presence of curvilinearity. Therefore, functional terms were added to the variable list as suggested by Kim and Kahout. These additional variables are listed in Table II.

The SPSS computer program is designed to provide the user with a considerable number of control options. The listwise deletion option was chosen for use by the author as it is the most conservative and accurate of the options.

The forward (stepwise) multiple regression technique (Appendix C) is particularly useful in studies of the current type. It is appropriate to enter independent variables one by one on the basis of a pre-determined statistical criteria. This procedure is used when a researcher desires to isolate a subset of available predictor variables that will yield an optimal prediction equation with as few terms as possible.

Draper and Smith [1966] conclude the following in their discussion of various regression procedures: "We believe this (stepwise regression) to be the best of the variable selection procedures discussed and recommend its use." The percentage of the accident rate variability explained

TABLE II

CONSTRUCTED VARIABLES

1. AGE2 = $(AGE)^2$
2. TTIME2 = $(TTIME)^2$
3. TOT902 = $(TOT90)^2$
4. WINGS2 = $(WINGS)^2$
5. DAY902 = $(DAY90)^2$
6. CLDAY2 = $(CLDAY)^2$
7. CLNIT2 = $(CLNIT)^2$
8. ACHRS2 = $(ACHRS)^2$
9. EXPER2 = $(EXPER)^2$
10. DNA2 = $(DNA)^2$
11. NITE902 = $(NITE90)^2$
12. ACTOUR2 = $(ACTOUR)^2$
13. NITEDAY2 = $(NITEDAY)^2$
14. NITEDAYI = 1.0/NITEDAY2
15. AGEI = 1.0/AGE2
16. TTIMEI = 1.0/TTIME2
17. TOT90I = 1.0/TOT902
18. NITE90I = 1.0/NITE902
19. DAY90I = 1.0/DAY902
20. CLDAYI = 1.0/CLDAY2
21. CLNITI = 1.0/CLNIT2
22. ACTOURI = 1.0/ACTOUR2
23. ACHRSI = 1.0/ACHRS2
24. DNAI = 1.0/DNA2
25. EXPERI = 1.0/EXPER2
26. WINGSI = 1.0/WINGS2
27. RTAGE = $(AGE)^{\frac{1}{2}}$
28. RTDNA = $(DNA)^{\frac{1}{2}}$
29. RTTTIME = $(TTIME)^{\frac{1}{2}}$
30. RTTOT90 = $(TOT90)^{\frac{1}{2}}$
31. RTDAY90 = $(DAY90)^{\frac{1}{2}}$
32. RTCLDAY = $(CLDAY)^{\frac{1}{2}}$
33. RTCLNIT = $(CLNIT)^{\frac{1}{2}}$
34. RTACHRS = $(ACHRS)^{\frac{1}{2}}$
35. RTEXPER = $(EXPER)^{\frac{1}{2}}$
36. RTWINGS = $(WINGS)^{\frac{1}{2}}$
37. RTNITE90 = $(NITE90)^{\frac{1}{2}}$
38. RTACTOUR = $(ACTOUR)^{\frac{1}{2}}$
39. RTNITEDAY = $(NITEDAY)^{\frac{1}{2}}$

by the time related independent variables entered is exactly the type of statistical output required to ascertain the causal factors responsible for that variability.

Thirteen separate regression calculations were attempted for each of the eight commands considered. Each of the separate regression calculations were permutations of the variables listed in Table I and the variables listed in Table II. Regression calculations using only the first eight variables of Table I or regression calculations using the first ten variables of Table I led to the suspicion of curvilinearity in the data as a result of an inspection of the residual scatter plots. Therefore, the author attempted various regression calculations using combinations of the variables of Table I with either the squares of those variables, the inverse squares of those variables, the square roots of those variables or any combinations thereof.

There is no unique procedure for selecting the best criteria and personal judgement is a necessary part of any decision reached by the analyst. The author set up guidelines to choose the "best" equation as follows: (1) the regression equation would be limited to five or six independent variables; (2) the regression equation chosen should account for the highest amount of the variance in aircraft accident rate; (3) the residual plots would be examined for the best indication of minimum residuals; and (4) the statistical significance of each regression would be calculated as outlined in Appendix D and the regression equation

yielding the greatest amount of accountable variance with the highest confidence level would be the equation selected.

IV. RESULTS

A. COMNAVAIRLANT

Early efforts at regression analysis by the author used only the variables listed in Table I. These efforts led to the suspicion of curvilinearity as a result of examination of the residual plots. The order of variable inclusion at the early stage was: (1) total flight time during the ninety days preceding the accident (TOT90); and (2) aircraft flight hours since the last major or minor inspection (ACHRS). In equation form the regression became:

$$RATE = 0.35295 + 0.00658(TOT90) + 0.00163(ACHRS)$$

This equation accounted for 19.5% of the variance in aircraft accident rate at a 95% confidence level.

Final regression results using functional forms of the variables indicated that the hierarchical order of variable inclusion as governed by the individual variable contributions towards explaining accident rate variance was: (1) the square root of aircraft flight hours since the last major or minor inspection (RTACHRS); (2) the square of aircraft flight hours since the last major or minor inspection (ACHRS2); (3) the inverse square of the total flight time during the ninety days preceding the accident (TOT90I); (4) the inverse square of the quotient years experience as a designated Naval aviator and total flight time in the accident involved

aircraft model (EXPERI); and (5) the square root of the quotient years experience as a designated Naval aviator and total flight time in the accident involved aircraft model (RTEXPER). Table III lists the simple correlation coefficients and Table IV is a summary listing of computer output provided by the SPSS package. In equation form the regression became:

$$\begin{aligned} RATE = {} & 0.89771 + 0.11823(RTACHRS) - 0.00002(ACHRS2) \\ & - 464.21653(TOT90I) - 0.00002(EXPERI) \\ & - 4.76996(RTEXPER) \end{aligned}$$

or in terms of Table I variables

$$\begin{aligned} RATE = {} & 0.89771 + 0.11823(ACHRS)^{\frac{1}{2}} - 0.00002(ACHRS)^{2} \\ & - 464.21653(TOT90)^{2} - 0.00002(TTIME/DNA)^{2} \\ & - 4.76996(DNA/TTIME)^{\frac{1}{2}} \end{aligned}$$

These equations account for 42.9% of the variance in aircraft accident rate at a 99% confidence level. Therefore, by using functional forms of the variables, an additional 23.4% of the variance was accounted for--a substantial improvement in the results.

The net effect of the functional forms of hours since the last major or minor inspection is positive. The remaining variables are interpreted as being measures of either pilot experience or pilot proficiency and they have a net effect of reducing aircraft accident rate.

TABLE III

COMNAVAIRLANT MATRIX OF
SIMPLE CORRELATION COEFFICIENTS

	RATE	RTACHRS	ACHRS2	TOT90I	EXPERI	RTEXPER
RATE	1.00000	0.43005	0.25440	-0.40206	-0.20680	-0.05688
RTACHRS	0.43005	1.00000	0.91023	-0.25434	0.10231	-0.15503
ACHRS2	0.25440	0.91023	1.00000	-0.24884	0.21916	-0.24819
TOT90I	-0.40206	-0.25434	-0.24884	1.00000	-0.23925	0.29086
EXPERI	-0.20680	0.10231	0.21916	-0.23925	1.00000	-0.74325
RTEXPER	-0.05688	-0.15503	-0.24819	0.29086	-0.74325	1.00000

NOTE: All correlation matrices in this chapter contain only those variables which yield a major contribution in accounting for accident rates and do not show all fifty-nine functional forms considered in the study.

TABLE IV

COMNAVAIRLANT REGRESSION OUTPUT SUMMARY

VARIABLE	MULTIPLE R	R SQUARE	R SQUARE ADJUSTED	REGRESSION COEFFICIENT B	BETA
RTACHRS	0.43005	0.18494	0.18494	0.11823	0.96393
ACHRS2	0.54264	0.29446	0.27170	-0.00002	-0.68624
TOT90I	0.62858	0.39512	0.35479	-464.21653	-0.34567
EXPERI	0.67061	0.44971	0.39279	-0.00002	-0.49331
RTEXPER	0.70747	0.50052	0.42916	-4.76996	-0.34387
(CONSTANT)				0.89771	

B. MARLANT

Using the same early methods as those used for COMNAVAIRLANT the order of variable inclusion at the early stage was: (1) years experience as a designated Naval aviator (DNA); (2) daylight carrier landings during the preceding thirty days (CLDAY); (3) the quotient of years experience as a designated Naval aviator and total flight time in the accident involved aircraft model (EXPER); (4) the quotient of night flight hours to day flight hours during the preceding ninety days (NITEDAY); and (5) total flight time in accident involved aircraft model. In equation form the regression became:

$$\begin{aligned} \text{RATE} = {} & 0.96753 + 0.09865(\text{DNA}) + 0.08248(\text{CLDAY}) \\ & - 20.27987(\text{EXPER}) + 1.41098(\text{NITEDAY}) \\ & - 0.00048(\text{TTIME}) \end{aligned}$$

This equation accounted for 32.6% of the variance in aircraft accident rate at a 75% confidence level.

Final regression results using functions of the variables indicated that the hierarchical order of variable inclusion as governed by the individual variable contributions towards explaining accident rate variance was: (1) the square root of years experience as a designated Naval aviator (RTDNA); (2) the square root of total night flight time during the preceding ninety nights (RTNITE90); (3) total night flight time during the

preceding ninety nights (NITE90); (4) the quotient of years experience as a designated Naval aviator and total flight time in the accident involved aircraft model (EXPER); (5) total flight time in the accident involved aircraft model (TTIME); and (6) the square of night carrier landings during the preceding thirty nights (CLNIT2). Table V lists the simple correlation coefficients and Table VI is a summary listing of computer output provided by the SPSS package. In equation form the regression became:

$$
\begin{aligned}
\text{RATE} = {} & -0.17128 + 0.88657(\text{RTDNA}) + 0.52634(\text{RTNITE90}) \\
& -0.06351(\text{NITE90}) - 57.37027(\text{EXPER}) - 0.00115(\text{TTIME}) \\
& + 0.21877(\text{CLNIT2})
\end{aligned}
$$

or in terms of Table I variables

$$
\begin{aligned}
\text{RATE} = {} & -0.17128 + 0.88657(\text{DNA})^{\frac{1}{2}} + 0.52634(\text{NITE90})^{\frac{1}{2}} \\
& - 0.06351(\text{NITE90}) - 57.37027(\text{DNA/TTIME}) \\
& - 0.00115(\text{TTIME}) + 0.21877(\text{CLNIT})^{2}
\end{aligned}
$$

These equations account for 56.5% of the variance in aircraft accident rate at a 99% confidence level versus the 32.6% accounted for initially. A substantial improvement was again observed when using functional forms of the variables in the regression analysis.

When reviewing the correlation matrix (Table V) it is noted that every variable present in the equation is positively correlated with accident rate except for EXPER (a measure of pilot experience) and the square of night carrier landings in the last thirty days (a measure of pilot

proficiency). The net affect of the functional forms of night flight hours during the last ninety nights is positive, an indication that night flying may be a hazardous evolution and add to accident rate.

TABLE V

MARLANT MATRIX OF SIMPLE
CORRELATION COEFFICIENTS

	RATE	RTDNA	RTNITE90	NITE90	EXPER	TTIME	CLNIT2
RATE	1.00000	0.37513	0.25962	0.15421	-0.13630	0.21877	-0.10418
RTDNA	0.37513	1.00000	-0.33433	-0.25966	0.19231	0.53821	0.03470
RTNITE90	0.25962	-0.33433	1.00000	0.94715	-0.18814	0.06561	-0.05614
NITE90	0.15421	-0.25966	0.94715	1.00000	-0.21438	0.15800	-0.08847
EXPER	-0.13630	0.19231	-0.18814	-0.21438	1.00000	-0.41257	0.88450
TTIME	0.21877	0.53821	0.06561	0.15800	-0.41257	1.00000	-0.25426
CLNIT2	-0.10418	0.03470	-0.05614	-0.08847	0.88450	-0.25426	1.00000

TABLE VI

MARLANT REGRESSION OUTPUT SUMMARY

VARIABLE	MULTIPLE R	R SQUARE	R SQUARE ADJUSTED	REGRESSION COEFFICIENT B	BETA
RTDNA	0.37513	0.14072	0.14072	0.88657	1.29302
RTNITE90	0.55464	0.30763	0.27994	0.52634	1.52286
NITE90	0.67524	0.45594	0.41061	-0.06351	-1.06959
EXPER	0.70936	0.50319	0.43839	-57.37027	-1.54330
TTIME	0.73502	0.54026	0.45667	-0.00115	-0.78892
CLNIT2	0.80524	0.64841	0.56470	0.06901	1.00628
(CONSTANT)				-0.17128	

C. COMNAVAIRPAC

Initial efforts yielded the following order of variable inclusion: (1) total flight time during the preceding ninety days (DAY90); (2) the number of aircraft tours (ACTOUR); and (3) years experience as a designated Naval aviator. In equation form the regression became:

$$\text{RATE} = -0.07944 + 0.01289(\text{DAY90}) + 0.10561(\text{ACTOUR}) + 0.04137(\text{DNA})$$

This equation accounted for 33.8% of the variance in aircraft accident rate at a 99% confidence level.

Final regression results using functions of the variables indicated that the hierarchical order of variable inclusion as governed by the individual variable contributions towards explaining accident rate variance was: (1) the inverse square of total day flight time during the preceding ninety days (DAY90I); (2) the square of the age of the pilot at designation as a Naval aviator (WINGS2); (3) the number of aircraft tours (ACTOUR); (4) the inverse square of aircraft hours since the last major or minor inspection (ACHRSI); and (5) the square of the hours since the last major or minor inspection (ACHRS2). Table VII lists the simple correlation coefficients and Table VIII is a summary listing of computer output provided by the SPSS package. In equation form the regression became:

$$\text{RATE} = 1.47479 - 670.77272(\text{DAY90I}) - 0.00134(\text{WINGS2})$$
$$+ 0.15733(\text{ACTOUR}) + 304.94442(\text{ACHRSI})$$
$$+ 0.00001(\text{ACHRS2})$$

or in terms of Table I variables

$$\text{RATE} = 1.47479 - 670.77272/(\text{DAY90})^2 - 0.00134(\text{AGE} - \text{DNA})^2$$
$$+ 0.15733(\text{ACTOUR}) + 304.94442(\text{ACHRS})^2$$
$$+ 0.00001(\text{ACHRS})^2$$

These equations account for 45.7% of the variance in aircraft accident rate at a 99.5% confidence level, an increase of 11.9% in accounting for variance.

It is noted in these equations that the number of aircraft tours and functional forms of hours since the last major or minor inspection have a positive effect on accident rate. Conversely, variables interpreted as measures of pilot proficiency and experience level have a negative effect.

TABLE VII

COMNAVAIRPAC MATRIX OF
SIMPLE CORRELATION COEFFICIENTS

	RATE	DAY90I	WINGS2	ACTOUR	ACHRSI	ACHRS2
RATE	1.00000	-0.50115	-0.34647	0.21622	-0.16796	0.23537
DAY90I	-0.50115	1.00000	0.05582	0.14874	0.71008	-0.32403
WINGS2	-0.34647	0.05582	1.00000	-0.21402	-0.13898	-0.04226
ACTOUR	0.21622	0.14874	-0.21402	1.00000	0.07584	-0.34793
ACHRSI	-0.16796	0.71008	-0.13898	0.07584	1.00000	-0.44262
ACHRS2	0.23537	-0.32403	-0.04226	-0.34793	-0.44262	1.00000

TABLE VIII

COMNAVAIRPAC REGRESSION OUTPUT SUMMARY

VARIABLE	MULTIPLE R	R SQUARE	R SQUARE ADJUSTED	REGRESSION COEFFICIENT B	BETA
DAY90I	0.50115	0.25115	0.25115	-670.77272	-0.79294
WINGS2	0.59406	0.35291	0.33330	- 0.00134	-0.13966
ACTOUR	0.63633	0.40492	0.36773	0.15733	0.37879
ACHRSI	0.67249	0.45224	0.39923	304.94442	0.48892
ACHRS2	0.72183	0.52104	0.45718	0.00001	0.32074
(CONSTANT)				1.47479	

D. MARPAC

Initial efforts at regression analysis yielded very poor results for this command. The only variable to be included in the equation was the quotient of night flight hours to day flight hours during the preceding ninety days. In equation form the regression became:

$$RATE = 1.75337 - 2.47720(NITE90/DAY90)$$

This equation accounted for 9.2% of the variance in aircraft accident rate at a 75% confidence level.

Further regression efforts using functions of the variables led to much better results with the hierarchical order of variable inclusion being: (1) the square of the number of aircraft tours (ACTOUR2); (2) the number of aircraft tours (ACTOUR); (3) the square of total night flight time during the preceding ninety nights (NITE902); (4) the square of the quotient total night flight hours to total day flight hours during the preceding ninety days (NITEDAY2); (5) aircraft flight hours since the last major or minor inspection (ACHRS); and (6) the square of age at designation as a Naval aviator (WINGS2). Table IX lists the simple correlation coefficients and Table X is a summary listing of computer output provided by the SPSS package. In equation form the regression became:

$$\begin{aligned} RATE = {} & 1.26335 - 0.32047(ACTOUR2) + 2.21178(ACTOUR) \\ & + 0.01042(NITE902) - 19.20769(NITEDAY2) \\ & - 0.00565(ACHRS) - 0.00462(WINGS2) \end{aligned}$$

or in terms of Table I variables

$$\begin{aligned} RATE = {} & 1.26335 - 0.32047(ACTOUR)^2 + 2.21178(ACTOUR) \\ & + 0.01042(NITE90)^2 - 19.20769(NITE90/DAY90)^2 \\ & - 0.00565(ACHRS) - 0.00462(AGE\text{-}DNA)^2 \end{aligned}$$

Either equation accounts for 39.2% of the variance in aircraft accident rate at a 95% confidence level, a substantial improvement over the 9.2% of variance accounted for initially.

Reviewing the correlation matrix it is noted that every variable present in the equation is negatively correlated with accident rate. However, the intercorrelations of the variables has the affect of causing some of the signs of the coefficients in the equation to change, with the net effect of the functional forms of aircraft tours being positive.

TABLE IX

MARPAC MATRIX OF SIMPLE CORRELATION COEFFICIENTS

	RATE	ACTOUR2	ACTOUR	NITE902	NITEDAY2	ACHRS	WINGS2
RATE	1.0000	-0.26720	-0.20851	-0.03585	-0.12062	-0.15731	-0.13797
ACTOUR2	-0.26720	1.00000	0.97846	0.63038	0.35437	0.13185	0.16754
ACTOUR	-0.20851	0.97846	1.00000	0.55089	0.34348	0.15143	0.17695
NITE902	-0.03585	0.63038	0.55089	1.00000	0.66647	0.15339	0.35599
NITEDAY2	-0.12062	0.35437	0.34348	0.66647	1.00000	-0.08745	0.35962
ACHRS	-0.15731	0.13185	0.15143	0.15339	-0.08745	1.00000	-0.07843
WINGS2	-0.13797	0.16754	0.17695	0.35599	0.35962	-0.07843	1.00000

TABLE X

MARPAC REGRESSION OUTPUT SUMMARY

VARIABLE	MULTIPLE R	R SQUARE	R SQUARE ADJUSTED	REGRESSION COEFFICIENT B	BETA
ACTOUR2	0.26720	0.07139	0.07139	-0.32047	-3.94096
ACTOUR	0.37030	0.13712	0.10737	2.21178	3.31033
NITE902	0.47848	0.22895	0.17387	0.01042	1.17134
NITEDAY2	0.56419	0.31831	0.24257	-19.20769	-0.56529
ACHRS	0.64657	0.41805	0.32852	-0.00565	-0.39225
WINGS2	0.70225	0.49315	0.39178	-0.00462	-0.30796
(CONSTANT)				1.26335	

E. CNATRA

All attempts at regression analysis for this command yielded essentially the same results. Early efforts using only the variables listed in Table I yielded the following order of variable inclusion: (1) the quotient of total night flight hours to total day flight hours during the preceding ninety days (NITEDAY); (2) total flight time in accident involved aircraft model (TTIME); (3) the quotient of total flight time in accident involved aircraft model to years experience as a designated Naval aviator (TTIME/DNA); (4) aircraft flight hours since the last major or minor inspection (ACHRS); and (5) the quotient of years experience as a designated Naval aviator to total flight time in accident involved aircraft model. In equation form the regression became:

$$\begin{aligned}\text{RATE} = {} & 5.22976 + 51.98496(\text{NITE90/DAY90}) + 0.00955(\text{TTIME}) \\ & - 0.01973(\text{TTIME/DNA}) - 0.04198(\text{ACHRS}) \\ & - 216.41848(\text{DNA/TTIME})\end{aligned}$$

This equation accounted for 32.3% of the variance in aircraft accident rate at a 90% confidence level.

Later regression results using functions of the variables yielded: (1) the square root of aircraft flight hours since the last major or minor accident (RTACHRS); (2) the square of aircraft hours since the last major or minor inspection

(ACHRS); (3) the square of the total day flight hours flown during the preceding ninety days (DAY902); (4) the square root of the quotient of total flight time in the accident involved aircraft model to years experience as a designated Naval aviator (1.0/RTEXPER); and (5) the quotient of total flight time in accident involved aircraft model and years experience as a designated Naval aviator. Table XI lists the simple correlation coefficients and Table XII is a summary listing of computer output provided by the SPSS package. In equation form the regression became:

$$\begin{aligned} \text{RATE} = {} & -0.31346 + 0.11248(\text{RTACHRS}) - 0.00003(\text{ACHRS2}) \\ & - 0.00002(\text{DAY902}) + 0.03482(1.0/\text{RTEXPER}) \\ & - 0.00092(1.0/\text{EXPER}) \end{aligned}$$

or in terms of Table I variables

$$\begin{aligned} \text{RATE} = {} & -0.31346 + 0.11248(\text{ACHRS})^{\frac{1}{2}} - 0.00003(\text{ACHRS})^{2} \\ & - 0.00002(\text{DAY90})^{2} + 0.03482(\text{TTIME}/\text{DNA})^{\frac{1}{2}} \\ & - 0.00092(\text{TTIME}/\text{DNA}) \end{aligned}$$

Either equation accounts for 33.0% of the variance in aircraft rate at a confidence level of 90%; representing no significant change in the results. The functional forms of aircraft hours since the last major or minor inspection and the reciprocal forms of EXPER have a net positive effect while the square of day flight time during the last ninety days has a negative affect.

TABLE XI

CNATRA MATRIX OF SIMPLE CORRELATION COEFFICIENTS

	RATE	RTACHRS	ACHRS2	DAY902	1.0/RTEXPER	1.0/EXPER
RATE	1.00000	0.27841	0.07831	-0.25511	0.14338	0.09355
RTACHRS	0.27841	1.00000	0.88809	0.14088	-0.10909	0.03077
ACHRS2	0.07831	0.88809	1.00000	0.08602	0.12738	0.08995
DAY902	-0.25511	0.14088	0.08602	1.00000	0.14498	0.12742
1.0/RTEXPER	0.14338	-0.10909	0.12738	0.14498	1.00000	0.94870
1.0/EXPER	0.09355	0.03077	0.08995	0.12742	0.94870	1.00000

TABLE XII

CNATRA REGRESSION OUTPUT SUMMARY

VARIABLE	MULTIPLE R	R SQUARE	R SQUARE ADJUSTED	REGRESSION COEFFICIENT B	BETA
RTACHRS	0.27841	0.07751	0.07751	0.11248	1.23284
ACHRS2	0.46107	0.21259	0.18343	-0.00003	-1.03735
DAY902	0.56705	0.32154	0.26936	-0.00002	-0.38550
1.0/RTEXPER	0.62331	0.38851	0.31514	0.03482	0.85959
1.0/EXPER	0.65255	0.42582	0.33012	-0.00092	-0.61744
(CONSTANT)				-0.31346	

F. NAVAL RESERVES

Initial efforts yielded the following order of variable inclusion: (1) total night flight time during the preceding ninety nights (NITE90); (2) the quotient of total night flight time and total day flight time during the preceding ninety days and nights (NITE90/DAY90); (3) total flight time during the ninety days preceding the accident (TOT90); and (4) the number of daylight carrier landings during the preceding thirty days. In equation form the regression became:

$$\text{RATE} = 0.97395 + 0.06986(\text{NITE90}) - 1.22954(\text{NITE90/DAY90})$$
$$- 0.00777(\text{TOT90}) - 0.03343(\text{CLDAY})$$

This equation accounted for 71.4% of the variance in aircraft accident rate at a 99% confidence level.

Final regression results using functions of the variables indicated that the hierarchical order of variable inclusion as governed by the individual variable contributions towards explaining aircraft accident rate variance was: (1) the square of total night flight time during the preceding ninety nights (NITE902); (2) the square of the quotient of total night flight time and total day flight time during the preceding ninety days (NITEDAY2); (3) the inverse square of aircraft flight hours since the last major or minor inspection (ACHRSI); (4) the square root of daylight carrier landings during the preceding thirty days; and

(5) the inverse square of the quotient of years experience as a designated Naval aviator and total flight time in the accident involved aircraft model (EXPERI). Table XIII lists the simple correlation coefficients and Table XIV is a summary listing of computer output provided by the SPSS package. In equation form the regression became:

$$\text{RATE} = 0.83553 + 0.00084(\text{NITE902}) - 0.56367(\text{NITEDAY2})$$
$$-311.23233(\text{ACHRSI}) - 0.22889(\text{RTCLDAY})$$
$$+ 0.00002(\text{EXPERI})$$

or in terms of Table I variables

$$\text{RATE} = 0.83553 + 0.00084(\text{NITE90})^2 - 0.56367(\text{NITE90/DAY90})^2$$
$$- 311.23233(1.0/\text{ACHRS})^2 - 0.22889(\text{CLDAY})^{\frac{1}{2}}$$
$$+ 0.00002(\text{TTIME/DNA})^2$$

Either equation accounts for 81.3% of the variance in aircraft accident rate at a 99.9% confidence level, a 9.9% increase of accountable variance over initial efforts. The net effect of the square of night flight hours during the preceding ninety nights and the quotient of night flight hours and day flight hours during the preceding ninety nights and days is negative. This may indicate that the higher the ratio of night flight hours to day flight hours (a measure of pilot proficiency), the lower the accident rate.

TABLE XIII

NAVAL RESERVES MATRIX OF SIMPLE CORRELATION COEFFICIENTS

	RATE	NITE902	NITEDAY2	ACHRSI	RTCLDAY	EXPERI
RATE	1.00000	0.83134	0.08402	-0.24060	-0.17569	0.05267
NITE902	0.83134	1.00000	0.35207	-0.12089	-0.08687	0.06742
NITEDAY2	0.08402	0.35207	1.00000	-0.20677	-0.15749	-0.16243
ACHRSI	-0.24060	-0.12089	-0.20677	1.00000	-0.20140	0.38120
RTCLDAY	-0.17569	-0.08687	-0.15749	-0.20140	1.00000	0.55420
EXPERI	0.05267	0.06742	-0.16243	0.38120	0.55420	1.00000

TABLE XIV

NAVAL RESERVES REGRESSION OUTPUT SUMMARY

VARIABLE	MULTIPLE R	R SQUARE	ADJUSTED R SQUARE	REGRESSION COEFFICIENT B	BETA
NITE902	0.83134	0.69112	0.69112	0.00084	0.82757
NITEDAY2	0.86071	0.74082	0.72462	-0.56367	-0.30589
ACHRSI	0.88003	0.77446	0.74439	-311.23233	-0.42165
RTCLDAY	0.89946	0.80903	0.76811	-0.22889	-0.42823
EXPERI	0.92583	0.85716	0.81321	0.00002	0.34525
(CONSTANT)				0.83553	

G. MARTC

Initial efforts using only the variables of Table I yielded the following order of variable inclusion: (1) the quotient of total night flight hours and total day flight hours during the preceding ninety days (NITEDAY); (2) total flight time in accident involved aircraft model (TTIME); (3) the quotient of total flight time in accident involved aircraft model and years designated as a Naval aviator (TTIME/DNA); (4) age at designation as a Naval aviator (WINGS); and (5) number of aircraft tours (ACTOUR). In equation form the regression became:

$$\text{RATE} = -45.84436 + 32.23927(\text{NITEDAY}) + 0.02707(\text{TTIME})$$
$$- 0.15004(1.0/\text{EXPER}) + 2.20096(\text{WINGS})$$
$$- 0.75295(\text{ACTOUR})$$

This equation accounted for 68.0% of the variance in aircraft accident rate at a 95% confidence level.

Final regression results using functions of the variables indicated that the hierarchical order of variable inclusion as governed by the individual variable contributions towards explaining aircraft accident rate variance was: (1) the square of the quotient total night flight time and total day flight time during the preceding ninety days (NITEDAY2); (2) total flight time in accident involved aircraft model (TTIME); (3) the inverse square of the quotient years experience as a designated Naval aviator and total flight time in

the accident involved aircraft model (EXPERI); (4) total night flight time during the preceding ninety nights (NITE90); and (5) the square of age at designation as a Naval aviator (WINGS2). Table XV lists the simple correlation coefficients and Table XVI is a summary listing of computer output provided by the SPSS package. In equation form the regression became:

$$\begin{aligned} \text{RATE} = &- 0.36132 + 65.28325(\text{NITEDAY2}) + 0.00328(\text{TTIME}) \\ &- 0.00008(\text{EXPERI}) - 0.41913(\text{NITE90}) \\ &+ 0.00385(\text{WINGS2}) \end{aligned}$$

or in terms of Table I variables

$$\begin{aligned} \text{RATE} = &- 0.36132 + 65.28325(\text{NITE90/DAY90})^2 + 0.00328(\text{TTIME}) \\ &- 0.00008(\text{TTIME/DNA})^2 - 0.41913(\text{NITE90}) \\ &+ 0.00385(\text{AGE-DNA})^2 \end{aligned}$$

Either equation accounts for 79.9% of the variance in aircraft accident rate at a 95% confidence level, a 10.9% increase of accountable variance over initial efforts.

It should be noted for this command that only one variable interpreted as a measure of experience (EXPERI) is negatively correlated with accident rate. Another measure of experience (WINGS2) and three variables interpreted as measures of pilot proficiency are all positively correlated with accident rate. This positive correlation of pilot proficiency and experience variables is contrary to what the author hypothesized. The study by Poock [1976] also concluded that this command produced unusual results.

TABLE XV

MARTC MATRIX OF SIMPLE
CORRELATION COEFFICIENTS

	RATE	NITEDAY2	TTIME	EXPERI	NITE90	WINGS2
RATE	1.00000	0.63740	0.34126	-0.02274	0.47574	0.27644
NITEDAY2	0.63740	1.00000	0.03787	-0.02715	0.85314	0.38999
TTIME	0.34126	0.03787	1.00000	0.81683	0.26973	-0.00000
EXPERI	-0.02274	-0.02715	0.81683	1.00000	0.19937	0.14495
NITE90	0.47574	0.85314	0.26973	0.19937	1.00000	0.43669
WINGS2	0.27644	0.38999	-0.00000	0.14495	0.43669	1.00000

TABLE XVI

MARTC REGRESSION OUTPUT SUMMARY

VARIABLE	MULTIPLE R	R SQUARE	R SQUARE ADJUSTED	REGRESSION COEFFICIENT B	BETA
NITEDAY2	0.63740	0.40628	0.40628	65.28325	1.04460
TTIME	0.71203	0.50699	0.46907	0.00328	1.22623
EXPERI	0.84880	0.72046	0.67387	-0.00008	-0.90071
NITE90	0.88821	0.78892	0.73136	-0.41913	-0.69994
WINGS2	0.92530	0.85618	0.79865	0.00385	0.30528
(CONSTANT)				-0.36132	

H. RDT&E/NASC

These two commands were grouped together due to the fact that neither command had enough data points to be analyzed if considered as individual commands. Initial efforts using only the variables of Table I yielded the following order of variable inclusion: (1) total night flight hours during the preceding ninety nights (NITE90); (2) the quotient of years experience as a designated Naval aviator and total flight time in accident involved aircraft model (EXPER); and (3) pilot's age. In equation form the regression became:

$$\text{RATE} = 0.93622 - 0.08430(\text{NITE90}) + 0.31653(\text{EXPER}) - 0.01623(\text{AGE})$$

This equation accounted for 56.5% of the variance in aircraft accident rate at a 95% confidence level.

Final regression results using functions of the variables indicated that the hierarchical order of variable inclusion as governed by the individual variable contributions towards explaining aircraft accident rate variance was: (1) the square of total night flight during the preceding ninety nights (NITE902); (2) the square root of total flight time in accident involved aircraft model (RTTTIME); (3) the inverse square of years experience as a designated Naval aviator (DNAI); (4) the square root of the inverse quotient

of years experience as a designated Naval aviator and total flight time in the accident involved aircraft model (1.0/RTEXPER); (5) the inverse square of total flight time during the preceding ninety days (TOT90I); and (6) the square root of total flight time during the preceding ninety days (RTTOT90). Table XVII lists the simple correlation coefficients and Table XVIII is a summary listing of computer output provided by the SPSS package. In equation form the regression became:

$$\begin{aligned} \text{RATE} = &- 1.21331 + 0.71262(\text{NITE902}) + 0.23598(\text{RTTTIME}) \\ &+ 19.68521(\text{DNAI}) - 0.61421(1.0/\text{RTEXPER}) \\ &+ 182.91525(\text{TOT90I}) + 0.38527(\text{RTTOT90}) \end{aligned}$$

or in terms of Table I variables

$$\begin{aligned} \text{RATE} = &- 1.21331 + 0.71262(\text{NITE90})^2 + 0.23598(\text{TTIME})^{\frac{1}{2}} \\ &+ 19.68521(1.0/\text{DNA}) - 0.61421(\text{TTIME}/\text{DNA})^{\frac{1}{2}} \\ &+ 182.91525(1.0/\text{TOT90})^2 + 0.38527(\text{TOT90})^{\frac{1}{2}} \end{aligned}$$

Either equation accounts for 80.8% of the variance in aircraft accident rate at a 95% confidence level, a 25.3% increase over initial efforts.

TABLE XVII

RDT&E/NASC MATRIX OF SIMPLE CORRELATION COEFFICIENTS

	RATE	NITE902	RTTTIME	DNAI	1.0/RTEXPER	TOT90I	RTTOT90
RATE	1.00000	0.53848	0.42623	0.10374	0.32597	-0.24029	0.37029
NITE902	0.53848	1.00000	0.07166	-0.16220	0.03935	-0.26972	0.02778
RTTTIME	0.42623	0.07166	1.00000	-0.16971	0.83805	-0.48617	0.64415
DNAI	0.10374	-0.16220	-0.16971	1.00000	0.30256	-0.15607	0.09213
1.0/RTEXPER	0.32597	0.03935	0.83805	0.30256	1.00000	-0.50912	0.64206
TOT90I	-0.24029	-0.26972	-0.48617	-0.15607	-0.50912	1.00000	-0.74120
RTTOT90	0.37029	0.02728	0.64415	0.09213	0.64206	-0.74120	1.00000

TABLE XVIII

RDT&E/NASC REGRESSION OUTPUT SUMMARY

VARIABLE	MULTIPLE R	R SQUARE	R SQUARE ADJUSTED	REGRESSION COEFFICIENT B	BETA
NITE902	0.53848	0.28996	0.28996	0.71262	0.81236
RTTTIME	0.66408	0.44101	0.39442	0.23598	1.94821
DNAI	0.71296	0.50831	0.41892	19.68521	1.13576
1.0/EXPER	0.84685	0.71716	0.63230	-0.61421	-1.72021
TOT90I	0.88087	0.77594	0.67636	182.91525	0.65776
RTTOT90	0.93906	0.88183	0.80797	0.38527	0.58057
(CONSTANT)				-1.21331	

V. DISCUSSION

Reviewing the results it can be seen that as functional forms of the variables were introduced into the regression analysis that more variance in aircraft accident rate was accounted for at a higher confidence level. This was true for all eight commands considered.

Observing the signs of the correlation coefficients listed in Table XIX, it can be seen that the variable EXPER, which is the ratio of years experience as a designated Naval aviator and total flight time in accident involved aircraft model, was negatively correlated with accident rate in all cases. This indicates that the more flight time in a particular aircraft model that a pilot possesses per year of designated Naval aviator service that he will become more safe and thus have fewer accidents. This could suggest that the more experienced a pilot becomes the larger a repertoire of near tragedies he has to draw from and thus the more reminders or analogies he has to compare with current situations.

Conversely, the variable CLNIT, which is the number of night carrier landings a pilot has during the last thirty nights, showed positive correlation with aircraft accident rate in the three commands where the variable was present (COMNAVAIRLANT, MARLANT, COMNAVAIRPAC). This may indicate

TABLE XIX

SIGNS OF CORRELATION COEFFICIENTS

VARIABLE	COMNAV AIRLANT	MARLANT	COMNAV AIRPAC	MARPAC	CNATRA	NAVRES	MARTC	RDT&E/ NASC
AGE	-	+	-	-	-	+	+	+
DNA	-	+	+	+	-	+	+	+
TTIME	-	+	+	-	-	+	+	+
WINGS	+	-	-	-	+	-	+	+
EXPER	-	-	-	-	-	-	-	-
TOT90	+	+	+	+	-	+	-	+
NITE90	+	+	+	+	-	+	+	+
DAY90	+	+	+	+	-	+	-	+
CLDAY	-	+	+	-	+	-		
CLNIT	+	+	+					
ACTOUR	-	+	+	-	+	-	+	+
ACHRS	+	-	+	-	+	-	+	-
NITEDAY	+	+	-	-	+	+	+	+

that night carrier landings are more taxing evolutions and tend to add to aircraft accident rate.

It has been common belief that pilot proficiency lessens aircraft accident rate. However, when again reviewing the correlation coefficients, it is observed that the correlation of total flight time during the preceding ninety days (TOT90) and day flight time during the preceding ninety days (DAY90) is positively correlated with aircraft accident rate except in the cases of CNATRA and MARTC (both training commands). It is also observed that the variable night flight time during the preceding ninety nights is positively correlated with aircraft accident rate in all commands except CNATRA. Considering that the training commands are on a schedule where the pilot should not experience fatigue, the positive correlation of these variables with aircraft accident rate would tend to indicate that if flight time is not uniformly spread out that practice does not necessarily make perfect and that a possible fatigue factor may be causing an increase in aircraft accident rate. Fatigue could be construed as having the majority of flight time during the preceding ninety days massed into a short period of time instead of being distributed uniformly over the ninety day period. (It is understood that data for a thirty day period is now being recorded.) Another explanation would support Goorney's supposition that pilot complacency may increase directly as the number of hours flown and thus contribute to aircraft accidents. In this case, new pilots in the training command

most likely will not become complacent or they will not receive their wings.

The remaining variables listed in Table XIX did not indicate a dominant sign of the correlation coefficient common to all commands. Therefore, the author will not attempt to explain the remaining variables individually.

When reviewing the results of the major commands considered, it should be noted that the variables most instrumental in explaining the variance in aircraft accident rate are not all pilot oriented variables as was shown in the Maxwell and Stucki study which was an overall Navy/ Marine study. The overall results don't seem to apply when taking a more microscopic look at individual commands. COMNAVAIRLANT, COMNAVAIRPAC, MARPAC, CNATRA and Naval Reserves regression equations all contain variables interpreted as being either related to experience level, pilot proficiency, or aircraft condition. Only MARLANT, MARTC, and RDT&E/NASC account for the variance in aircraft accident rate by variables interpreted as being pilot oriented variables in their respective regression equations. Condition of the aircraft must therefore also be considered when attempting to account for the variance in aircraft accident rate.

VI. RECOMMENDATIONS

The current study includes eight major commands in its treatment of aircraft accident rate. Functional forms of the variables produced the best results. For this type of study however, the author recommends that the distributions for each variable be ascertained and that these distributions whether they be gamma, beta, exponential, etc. be used in an attempt to analyze aircraft accident rate.

This study was limited to consideration of only accident involved pilots and accident involved aircraft. A future study could be done comparing these pilots and aircraft to accident free pilots and aircraft in order to ascertain whether these groups are from the same distribution. It would then be possible to ascertain critical points in a pilot's career or the life of an aircraft.

A more microscopic study than this study may seem appropriate. However, subdividing the data any further into Airwings may limit the analyst to only a small number of data points.

APPENDIX A

AVERAGE MONTHLY DATA POINT VALUES FOR MAJOR COMMANDS

TABLE A1

AVERAGE MONTHLY DATA POINTS COMNAVAIRLANT

YRMO	RATE	AGE	DNA	TTIME	TOT90	NITE90	CLDAY	CLNIT	ACTOUR	ACHRS
7107	1.67	28.29	5.43	491.14	86.71	19.00	7.50	3.50	3.14	92.43
7108	0.64	28.33	5.43	138.33	50.67	10.00	7.00	2.00	2.50	72.00
7109	0.39	30.50	8.00	829.50	60.50	8.50	0.00	0.00	1.50	32.50
7110	0.64	31.00	8.50	515.33	86.00	10.33	3.00	1.00	2.50	161.00
7111	0.43	31.00	7.00	1601.00	78.50	8.00	1.00	0.00	3.00	231.00
7112	1.25	28.60	4.40	354.00	90.00	14.40	0.00	0.00	3.50	104.40
7201	1.61	30.29	6.43	800.43	89.14	26.00	2.50	1.17	3.71	161.86
7202	0.72	32.67	9.67	331.00	45.33	11.33	2.33	1.33	3.00	60.00
7203	1.47	29.57	6.79	295.57	51.29	9.00	4.14	1.29	2.50	107.57
7204	1.55	30.14	6.79	572.43	56.86	9.43	2.57	1.14	2.57	81.57
7205	0.79	27.50	2.75	580.50	74.25	15.75	10.00	1.75	1.75	90.25
7206	1.65	28.25	4.86	395.25	86.38	13.13	7.43	2.29	2.83	177.63
7207	1.08	25.80	2.80	267.60	84.60	19.40	8.20	2.20	2.40	204.40
7208	1.08	28.50	4.17	587.67	66.67	9.33	5.33	1.17	4.67	94.67
7209	0.72	29.25	6.00	675.75	88.25	19.50	20.50	8.50	2.75	161.25
7211	0.98	31.00	5.88	632.80	97.80	28.40	10.20	5.20	2.00	194.40
7212	0.50	29.00	5.50	1085.50	53.00	8.00	0.00	0.00	2.50	18.00
7301	1.33	33.67	9.33	852.83	70.67	10.67	0.00	0.00	3.83	244.67
7303	0.69	29.00	6.00	437.33	73.67	15.67	4.67	0.00	4.00	94.67
7304	1.31	29.33	6.08	506.00	67.17	9.83	4.00	0.50	4.17	134.00
7305	0.96	29.60	4.60	611.60	54.00	17.60	7.40	2.80	2.20	97.80
7306	0.47	34.00	11.75	874.00	52.00	13.00	0.00	0.00	4.50	15.50
7307	1.20	31.20	9.88	1056.00	67.00	7.75	5.75	0.50	3.40	61.00
7308	1.10	31.25	8.63	617.50	50.00	7.00	0.00	0.00	5.25	123.75
7309	0.77	25.67	2.00	237.67	63.00	10.00	4.00	1.33	2.67	70.67
7310	0.60	25.00	2.00	119.67	27.33	8.67	4.67	2.00	2.67	151.33
7311	0.44	38.00	17.50	721.00	46.00	1.50	8.00	0.00	6.00	38.00
7312	0.63	29.00	4.00	543.00	76.50	20.50	21.00	3.00	2.50	27.00
7401	0.85	31.67	8.50	543.00	43.67	13.33	1.00	0.00	5.00	68.00

TABLE A1 (CONTINUED)

YRMO	RATE	AGE	DNA	TTIME	TOT90	NITE90	CLDAY	CLNIT	ACTOUR	ACHRS
7402	0.29	27.00	4.00	318.00	27.00	3.00	0.00	0.00	6.00	37.00
7403	1.00	29.33	6.25	411.25	47.50	16.67	1.33	0.00	4.00	65.50
7404	0.89	32.25	8.38	440.25	72.25	17.50	0.00	0.00	5.25	46.50
7405	0.86	31.50	7.50	632.50	51.00	10.25	5.65	1.00	3.00	27.25
AVG.	0.92	29.91	6.57	578.04	64.78	13.01	4.82	1.32	3.37	101.44

TABLE A2

AVERAGE MONTHLY DATA POINTS
MARLANT

YRMO	RATE	AGE	DNA	TTIME	TOT90	NITE90	CLDAY	CLNIT	ACTOUR	ACHRS
7108	0.69	33.00	8.00	717.00	13.00	0.00	0.00	0.00	2.00	431.00
7109	1.62	25.50	2.00	774.00	75.50	5.50	0.00	0.00	2.50	54.00
7111	0.72	26.00	3.00	1112.00	79.00	19.00	0.00	0.00	1.00	25.00
7201	1.47	28.50	4.50	673.00	80.00	1.50	0.00	0.00	1.00	48.00
7202	0.67	26.00	1.00	253.00	61.00	1.00	0.00	0.00	1.00	17.00
7203	1.09	25.50	1.50	307.00	85.00	15.50	0.00	0.00	1.50	9.00
7204	1.70	28.67	3.00	307.00	62.00	7.00	0.00	0.00	2.00	178.50
7205	0.66	24.00	1.00	80.00	72.00	7.00	0.00	0.00	3.00	117.00
7206	2.04	28.67	6.00	825.00	104.67	10.33	12.00	2.67	2.33	108.00
7207	0.80	27.00	1.00	140.00	44.00	3.00	0.00	0.00	3.00	173.00
7209	0.69	25.00	2.00	735.00	97.00	2.00	0.00	0.00	1.00	53.00
7210	0.71	26.00	3.00	773.00	99.00	2.00	0.00	0.00	1.00	265.00
7211	1.99	32.33	9.83	1174.33	69.67	2.33	3.67	1.33	1.33	76.33
7212	1.50	25.00	2.00	412.00	113.50	26.00	0.00	0.00	2.00	88.00
7302	0.73	29.00	2.00	129.00	31.00	8.00	0.00	0.00	1.00	35.00
7303	1.30	34.00	12.00	1072.00	62.50	1.50	0.00	0.00	1.00	112.00
7304	1.19	28.50	7.50	265.00	31.00	3.50	0.00	0.00	2.00	38.00
7305	1.77	33.00	7.17	680.67	37.00	3.33	0.00	0.00	3.33	114.33
7309	0.81	26.00	2.00	311.00	65.00	8.00	0.00	0.00	2.00	47.00
7310	1.99	26.67	2.00	254.67	50.00	9.00	0.00	0.00	1.00	118.00
7311	0.75	25.00	2.00	596.00	48.00	6.00	0.00	0.00	2.00	34.00
7312	0.88	27.00	2.00	967.00	197.00	34.00	0.00	0.00	1.00	73.00
7401	0.85	29.00	7.00	546.00	0.00	0.00	0.00	0.00	1.00	114.00
7402	0.80	28.00	3.00	701.00	52.00	1.00	0.00	0.00	1.00	194.00
7403	1.26	26.50	1.00	317.50	63.50	9.50	0.00	0.00	3.00	9.00
7404	0.63	29.00	2.00	707.00	66.00	2.00	0.00	0.00	2.00	17.00
7406	0.63	28.00	3.00	44.00	25.00	3.00	6.00	6.00	1.00	104.00
AVG.	1.11	27.81	3.72	550.86	66.05	7.31	0.80	0.37	1.70	98.22

NOTE: All tables of Appendix A have some months omitted due to the fact that there were no accidents for the particular command for the given month.

TABLE A3

AVERAGE MONTHLY DATA POINTS
COMNAVAIRPAC

YRMO	RATE	AGE	DNA	TTIME	TOT90	NITE90	CLDAY	CLNIT	ACTOUR	ACHRS
7107	0.33	26.50	1.50	256.50	28.00	2.00	0.00	0.00	4.00	66.00
7108	1.42	26.78	2.89	431.00	98.11	17.22	6.33	2.33	3.86	92.78
7109	1.26	27.75	4.38	471.25	83.63	12.63	3.00	0.75	3.80	87.17
7110	1.71	29.40	5.20	453.10	82.10	9.40	8.00	2.25	1.89	202.78
7111	1.36	31.61	6.19	270.50	63.75	11.63	6.83	2.17	1.88	131.88
7112	1.48	27.90	4.85	821.20	104.60	20.30	8.17	2.00	3.44	107.11
7201	1.42	26.88	3.75	288.50	72.13	16.50	9.63	1.13	2.50	130.25
7202	1.07	27.83	4.67	540.50	83.17	20.17	14.60	1.80	2.67	153.17
7203	0.79	30.20	6.30	445.40	70.40	33.80	9.80	3.80	2.20	162.40
7204	1.03	28.00	4.57	485.71	74.71	14.29	6.86	3.00	2.57	95.43
7205	1.11	30.13	6.44	612.50	104.88	10.50	8.88	0.75	2.75	106.38
7206	0.82	27.00	3.00	461.67	82.50	17.00	4.67	1.17	3.00	98.00
7207	1.22	29.71	5.00	791.00	93.29	18.00	6.00	3.00	4.29	70.60
7208	1.11	26.71	3.57	383.57	100.14	17.86	6.00	2.43	4.43	104.71
7209	1.20	29.71	6.57	410.57	70.29	8.00	9.93	1.43	3.57	123.14
7210	0.84	28.80	4.90	774.[illegible]0	72.60	19.20	11.33	6.33	2.83	114.17
7211	1.50	28.38	5.00	381.50	72.13	11.38	5.00	1.88	3.63	140.50
7212	1.81	26.88	3.13	478.50	88.25	17.38	9.33	1.67	4.38	89.00
7301	1.56	29.22	5.50	580.22	91.67	17.00	9.78	2.33	3.22	143.33
7302	0.81	26.00	2.50	249.75	41.50	9.25	3.67	0.67	4.50	104.00
7303	1.33	28.00	3.57	496.71	52.43	14.14	2.00	0.29	3.00	52.50
7304	0.97	28.60	4.80	634.20	77.40	17.60	4.25	2.00	2.60	45.80
7305	1.54	32.63	9.88	605.75	70.13	13.88	6.63	3.13	3.13	52.00
7306	1.44	28.86	6.21	543.43	62.29	8.00	6.43	1.57	4.17	68.67
7307	1.29	26.20	2.80	329.00	62.80	8.00	3.40	1.00	5.60	84.60
7308	1.04	28.40	4.60	699.20	70.00	13.00	3.75	0.75	3.60	29.40
7310	2.11	28.44	4.56	623.22	58.78	13.13	5.57	1.88	4.86	29.50
7311	1.09	30.25	7.75	775.50	50.25	8.25	1.50	0.25	2.25	66.50
7312	0.65	29.00	4.00	682.00	37.00	6.00	4.00	0.00	4.00	59.00

TABLE A3 (CONTINUED)

YRMO	RATE	AGE	DNA	TTIME	TOT90	NITE90	CLDAY	CLNIT	ACTOUR	ACHRS
7401	0.83	32.67	8.33	572.33	36.00	7.33	4.33	0.00	4.67	48.67
7402	0.73	30.67	8.00	437.33	24.33	4.33	0.00	0.00	3.67	16.67
7403	0.67	26.33	2.67	385.33	54.00	13.00	8.00	4.00	1.67	34.00
7404	0.41	32.50	6.00	408.50	57.50	9.50	6.50	1.00	2,00	87.50
7405	0.88	28.50	3.25	538.75	72.00	28.00	8.25	2.75	2.25	32.25
AVG.	1.16	28.69	4.86	517.48	69.39	13.77	6.16	1.74	3.32	89.04

TABLE A4

AVERAGE MONTHLY DATA POINTS
MARPAC

YRMO	RATE	AGE	DNA	TTIME	TOT90	NITE90	CLDAY	CLNIT	ACTOUR	ACHRS
7108	1.59	29.00	4.67	263.33	49.00	7.33	0.00	0.00	3.00	83.67
7109	1.60	25.67	2.33	575.00	74.00	7.67	0.00	0.00	2.67	142.33
7110	1.69	29.67	6.33	1203.33	36.33	5.33	0.00	0.00	3.33	57.00
7111	1.17	27.50	1.00	232.00	29.50	5.00	3.50	0.00	3.50	113.50
7112	2.79	28.60	4.50	1079.40	87.40	6.20	0.00	0.00	3.00	113.00
7201	1.25	26.50	2.00	321.00	39.00	6.00	0.00	0.00	3.00	13.00
7202	1.16	32.50	7.50	397.00	51.50	12.50	0.00	0.00	3.00	59.00
7203	1.02	34.50	9.75	315.00	31.50	3.50	0.00	0.00	5.00	128.50
7204	1.08	31.50	4.00	772.50	78.00	11.50	0.00	0.00	4.00	77.00
7205	1.44	27.33	3.33	431.67	43.67	7.33	0.00	0.00	2.67	66.67
7206	1.00	27.50	3.50	965.00	71.00	6.50	0.00	0.00	3.50	138.00
7207	3.01	25.83	2.17	422.33	50.33	4.00	0.00	0.00	2.17	87.17
7208	1.50	26.00	1.67	326.00	73.67	3.00	0.00	0.00	3.00	117.33
7210	0.99	28.00	4.50	439.50	63.00	3.00	0.00	0.00	2.50	121.00
7211	2.08	27.25	4.75	580.50	49.00	4.00	0.00	0.00	3.50	153.67
7212	1.60	26.00	1.67	394.00	34.00	6.00	0.00	0.00	3.67	27.00
7301	2.07	28.50	5.88	371.75	66.00	3.75	0.00	0.00	2.75	96.25
7302	1.14	25.00	1.50	269.50	95.50	2.50	0.00	0.00	3.50	256.00
7303	2.48	30.40	7.40	472.00	26.60	2.20	0.00	0.00	2.40	87.25
7304	1.48	31.33	7.00	831.67	78.67	7.33	0.00	0.00	5.67	29.33
7305	0.46	25.00	2.00	263.00	92.00	9.00	0.00	0.00	6.00	34.00
7306	0.54	29.00	5.00	1478.00	38.00	5.00	0.00	0.00	1.00	5.00
7307	0.55	26.00	3.00	463.00	46.00	0.00	0.00	0.00	2.00	76.00
7308	1.57	27.33	2.67	617.33	94.67	3.33	0.00	0.00	5.00	42.00
7311	4.74	30.57	6.71	605.57	74.29	13.86	0.00	0.00	4.17	17.00
7312	1.96	35.67	8.83	1367.67	70.00	8.67	0.00	0.00	2.50	43.00
7401	0.67	32.00	7.00	2285.00	102.00	23.00	0.00	0.00	7.00	179.00
7402	0.73	41.00	17.50	421.00	47.00	9.00	0.00	0.00	5.00	196.00

TABLE A4 (CONTINUED)

YRMO	RATE	AGE	DNA	TTIME	TOT90	NITE90	CLDAY	CLNIT	ACTOUR	ACHRS
7403	0.59	27.00	3.00	518.00	35.00	7.00	0.00	0.00	5.00	12.00
7405	1.70	27.67	4.00	469.67	50.67	4.00	0.00	0.00	2.33	22.67
7406	1.75	26.00	3.00	525.33	40.67	4.00	0.00	0.00	3.33	33.00
AVG.	1.53	28.91	4.78	634.71	58.62	6.50	0.11	0.00	3.52	84.72

NOTE: Accident of July 1971 deleted due to incomplete data.

TABLE A5

AVERAGE MONTHLY DATA POINTS
CNATRA

YRMO	RATE	AGE	DNA	TTIME	TOT90	NITE90	CLDAY	CLNIT	ACTOUR	ACHRS
7108	0.66	27.00	2.25	409.75	94.25	3.00	1.00	0.00	5.00	105.33
7109	0.49	24.67	1.67	621.67	114.00	11.00	0.00	0.00	2.67	134.33
7110	0.50	24.67	1.00	131.67	71.33	7.67	1.33	0.00	5.67	134.67
7111	0.49	32.00	7.83	217.33	59.00	5.67	0.00	0.00	3.33	27.33
7112	0.57	29.00	2.50	449.00	88.50	6.50	0.00	0.00	6.00	30.00
7201	0.21	24.00	1.00	165.00	41.00	4.00	0.00	0.00	2.00	16.00
7202	0.56	26.67	2.33	907.67	91.33	7.00	1.33	0.00	3.33	120.33
7204	0.79	24.00	0.60	406.60	89.80	22.00	1.40	0.00	4.00	134.80
7205	0.19	27.00	4.00	687.00	129.00	29.00	0.00	0.00	3.00	201.00
7206	0.22	23.00	0.00	130.00	76.00	9.00	1.00	0.00	5.00	62.00
7207	1.38	27.71	4.00	575.14	96.86	11.43	0.00	0.00	4.57	95.86
7208	0.94	23.80	0.67	179.17	63.17	9.40	0.00	0.00	3.25	79.00
7209	0.56	24.67	0.67	343.33	99.00	9.00	0.00	0.00	2.00	123.67
7210	0.38	27.00	2.50	359.50	78.00	2.00	0.00	0.00	3.50	116.00
7211	0.64	26.00	2.00	291.33	51.33	8.00	3.00	0.00	1.00	139.00
7212	0.82	27.00	2.00	96.50	27.50	3.00	30.00	0.00	5.00	110.50
7302	0.41	34.50	10.25	671.50	55.00	6.50	0.00	0.00	8.00	2.50
7303	0.21	29.00	5.00	159.00	159.00	1.00	0.00	0.00	3.00	103.00
7305	0.33	28.50	4.00	604.00	128.50	14.00	0.00	0.00	4.00	61.50
7306	0.38	26.00	1.00	622.00	131.50	15.50	2.50	0.00	1.00	48.00
7307	0.60	28.33	5.00	876.33	108.67	5.00	0.00	0.00	1.00	145.50
7309	0.69	25.33	3.00	521.33	79.00	8.00	2.00	0.00	3.00	52.67
7310	0.55	26.00	2.00	518.33	146.00	32.00	0.00	0.00	4.00	45.00
7311	0.21	27.00	3.00	1330.00	59.00	9.00	0.00	0.00	2.00	5.00
7312	0.31	26.00	3.00	956.00	119.00	11.00	0.00	0.00	4.00	27.00
7402	0.67	25.67	2.67	517.33	77.33	2.67	0.00	0.00	5.00	65.00
7403	0.46	23.50	0.00	77.00	71.50	10.50	0.00	0.00	1.00	81.00
7405	0.39	32.00	10.25	353.00	75.00	9.00	0.00	0.00	2.50	20.50
7406	0.21	27.00	3.00	521.00	112.00	19.00	0.00	0.00	6.00	58.00
AVG.	0.51	26.79	3.01	472.33	89.36	10.03	1.50	0.00	3.58	80.84

NOTE: Accidents of July 1971, January 1973, and January 1974 were deleted due to incomplete data.

TABLE A6

AVERAGE MONTHLY DATA POINTS
NAVAL RESERVES

YRMO	RATE	AGE	DNA	TTIME	TOT90	NITE90	CLDAY	CLNIT	ACTOUR	ACHRS
7108	0.53	36.00	12.00	1904.00	32.00	4.00	10.00	0.00	6.00	109.00
7110	0.59	37.00	12.00	342.00	27.00	0.00	0.00	0.00	6.00	41.00
7111	0.70	26.00	5.00	704.00	62.00	10.00	6.00	0.00	7.00	237.00
7204	0.62	28.00	4.00	494.00	32.00	8.00	0.00	0.00	2.00	31.00
7205	0.81	32.00	12.00	443.00	28.00	5.00	0.00	0.00	6.00	115.00
7207	0.61	29.00	5.00	245.00	16.00	7.00	0.00	0.00	7.00	80.00
7209	0.60	29.00	4.00	160.00	96.00	8.00	0.00	0.00	2.00	34.00
7210	1.25	35.00	10.00	126.00	40.50	1.50	0.00	0.00	5.00	130.00
7302	1.30	33.00	9.50	1480.00	35.00	8.50	0.00	0.00	3.00	62.50
7303	0.58	45.00	21.00	700.00	40.00	20.00	0.00	0.00	5.00	215.00
7304	1.25	34.50	10.50	504.50	40.50	6.00	0.00	0.00	7.00	128.50
7307	0.56	35.00	12.00	1112.00	34.00	0.00	0.00	0.00	8.00	59.00
7308	0.51	32.00	7.00	1097.00	33.00	3.00	0.00	0.00	4.00	19.00
7309	0.64	30.00	9.00	182.00	86.00	7.00	0.00	0.00	6.00	205.00
7312	2.52	37.50	14.75	1585.00	121.50	45.50	0.00	0.00	4.00	70.00
7403	0.66	28.00	4.00	57.00	10.00	1.00	0.00	0.00	4.00	39.00
7404	0.73	40.00	12.00	1153.00	22.00	7.00	0.00	0.00	6.00	47.00
7406	0.71	40.00	17.50	500.00	54.00	6.00	0.00	0.00	7.00	175.00
AVG.	0.84	33.72	10.07	710.47	44.97	8.19	0.89	0.00	5.28	99.83

NOTE: The accident in August 1972 was deleted due to incomplete data.

TABLE A7

AVERAGE MONTHLY DATA POINTS
MARTC

YRMO	RATE	AGE	DNA	TTIME	TOT90	NITE90	CLDAY	CLNIT	ACTOUR	ACHRS
7108	0.91	35.00	12.00	228.00	42.00	2.00	0.00	0.00	6.00	35.00
7109	1.64	29.00	4.00	109.00	36.00	4.00	0.00	0.00	8.00	129.00
7201	1.83	27.00	5.00	14.00	14.00	0.00	0.00	0.00	2.00	32.00
7203	3.20	38.00	17.50	732.00	27.00	2.00	0.00	0.00	7.00	42.50
7204	4.82	34.00	8.00	714.00	32.33	6.00	0.00	0.00	5.67	104.50
7207	1.85	32.50	10.00	257.50	55.50	1.00	0.00	0.00	7.50	191.50
7208	1.25	29.00	6.00	1187.00	50.00	3.00	0.00	0.00	8.00	52.00
7302	1.93	30.00	9.00	101.00	26.00	4.00	0.00	0.00	3.00	58.00
7304	1.67	31.00	6.00	32.00	31.00	2.00	0.00	0.00	8.00	29.00
7305	3.08	30.50	6.50	794.00	19.50	1.50	0.00	0.00	7.00	44.50
7306	1.80	33.00	12.00	472.00	29.00	1.00	0.00	0.00	2.00	209.00
7307	2.33	29.00	8.00	529.00	80.00	2.50	0.00	0.00	3.00	54.50
7308	2.55	32.50	9.50	323.00	32.50	2.00	0.00	0.00	6.00	102.00
7310	1.80	28.00	5.00	5.00	5.00	0.00	0.00	0.00	7.00	7.00
7402	2.52	40.00	17.50	60.00	21.00	3.00	0.00	0.00	8.00	85.00
AVG.	2.21	31.90	9.07	370.50	33.39	2.27	0.00	0.00	5.88	78.37

TABLE A8

AVERAGE MONTHLY DATA POINTS
RDT&E/NASC

YRMO	RATE	AGE	DNA	TTIME	TOT90	NITE90	CLDAY	CINIT	ACTOUR	ACHRS
7108	1.82	36.00	12.00	19.00	19.00	0.00	0.00	0.00	3.00	257.00
7109	2.01	28.00	4.00	60.00	20.00	0.00	0.00	0.00	4.00	2.00
7205	1.85	47.00	21.00	19.00	10.00	0.00	0.00	0.00	1.00	21.00
7206	3.67	33.50	2.00	158.50	36.00	0.00	0.00	0.00	2.50	1.50
7210	1.57	28.00	5.00	490.00	70.00	0.00	0.00	0.00	1.00	34.00
7211	1.86	27.00	4.00	13.00	13.00	0.00	0.00	0.00	1.00	56.00
7212	2.81	38.00	12.00	197.00	30.00	1.00	0.00	0.00	2.00	114.00
7302	2.09	37.00	12.00	770.00	20.00	0.00	0.00	0.00	2.00	3.00
7306	4.07	32.50	5.00	60.00	21.00	2.00	0.00	0.00	1.50	103.50
7307	3.26	31.00	6.00	94.00	8.50	0.00	0.00	0.00	2.50	80.50
7310	1.66	27.00	5.00	76.00	16.00	0.00	0.00	0.00	3.00	29.00
7311	3.70	33.50	11.75	219.00	35.00	1.50	0.00	0.00	2.50	28.50
7401	4.90	39.50	17.50	788.00	69.00	0.00	0.00	0.00	2.00	9.50
7406	3.99	33.00	8.00	812.50	27.00	1.50	0.00	0.00	4.00	28.00
AVG.	2.80	33.64	8.95	269.71	28.18	0.43	0.00	0.00	2.29	54.82

NOTE: Accidents of January 1972, September 1972, August 1973, April 1974, and May 1974 were deleted due to incomplete data.

APPENDIX B

AIRCRAFT ACCIDENTS BY MONTH AND BY COMMAND

YRMO	AIRLANT	MARLANT	AIRPAC	MARPAC	CNATRA	NAV RES	MARTC	RDT&E/NASC
7107	7	0	2	1	1	0	0	0
7108	3	1	9	3	4	1	1	1
7109	2	2	8	3	3	0	1	1
7110	3	0	10	3	3	1	0	0
7111	2	1	8	2	3	1	0	0
7112	5	0	10	5	2	0	0	0
7201	7	2	8	2	1	0	1	1
7202	3	1	6	2	3	0	0	0
7203	7	2	5	2	0	0	2	0
7204	7	3	7	2	5	1	3	0
7205	4	1	8	3	1	1	0	1
7206	8	3	6	2	1	0	0	3
7207	5	1	7	6	7	1	2	0
7208	6	0	7	3	6	1	1	0
7209	4	1	7	0	3	1	0	1
7210	1	1	5	2	2	2	0	1
7211	5	3	8	4	3	0	0	1
7212	2	2	9	3	2	0	0	1
7301	6	0	9	4	1	0	0	0
7302	0	1	4	2	2	1	1	1
7303	3	2	7	5	1	1	0	0
7304	6	2	5	3	0	2	1	0
7305	5	3	8	1	2	0	2	0
7306	2	0	7	1	2	0	1	2
7307	5	0	6	1	3	1	2	2
7308	4	0	5	3	0	1	2	1
7309	3	1	8	0	3	1	0	0
7310	3	3	9	0	3	0	1	1
7311	2	1	4	7	1	0	0	2
7312	2	1	2	3	1	2	0	0
7401	3	1	3	1	1	0	0	2

APPENDIX B (CONTINUED)

YRMO	AIRLANT	MARLANT	AIRPAC	MARPAC	CNATRA	NAV RES	MARTC	RDT&E/NASC
7402	1	1	3	1	3	0	1	0
7403	4	2	3	1	2	1	0	0
7404	4	1	2	0	0	1	0	1
7405	4	0	4	3	2	0	0	1
7406	0	1	0	3	1	1	0	2

APPENDIX C

FORWARD (STEPWISE) MULTIPLE REGRESSION

The basic principles of regression analysis may be extended to situations involving two or more independent variables. The general mathematical form of the (unstandardized) regression is

$$Y' = A + B_1X_1 + B_2X_2 + \dots + B_KX_K$$

where Y' represents the estimated value of the dependent variable, A is the Y intercept, the B_i are regression coefficients, and the X_i are the independent variables. It is assumed that this is a complete set of variables from which the equation is to be chosen and includes any functions such as squares and inverse squares thought to be desirable and necessary.

The A and B_i coefficients are selected in such a way as to minimize the sum of squared residuals, $\sum(Y-Y')^2$. By minimizing the squared residuals, the regression technique maximizes the correlation between the actual dependent variable (Y) and the estimated dependent variable (Y') while the correlation between the independent variables and the residual values (Y-Y') are reduced.

The proportion of variance of Y explained, i.e., the goodness of fit of the regression equation can be evaluated by examining the square of the multiple correlation (R^2), where R^2 is calculated by:

$$R^2 = \frac{SS_y - SS_{res}}{SS_y} = \frac{SS_{reg}}{SS_y} = \frac{\sum(Y' - \bar{Y})^2}{\sum(Y' - \bar{Y})^2 - \sum(Y - Y')^2}$$

or

$$R^2 = \frac{\text{variation in Y explained by the combined linear influence of the independent variables}}{\text{total variation in Y}}$$

where SS_y is the total variation or sum of squares in Y, SS_{res} is the sum of squared residuals, and SS_{reg} is the regression of squares.

The forward (stepwise) selection procedure available in the Statistical Package for the Social Sciences (SPSS version 6) used for this study inserts variables in turn until the regression equation is satisfactory. Independent variables are entered only if they meet certain statistical criteria. The order of inclusion is determined by the respective contribution of each variable that explains the greatest amount of variance previously unexplained by the variables already in the equation. The variable that does this is the next variable to be entered.

This order of insertion is determined by using the partial correlation coefficient as a measure of the importance of variables not yet in the equation. The basic procedure is as follows. First select the X most correlated with Y (suppose it is X_1) and find the linear regression equation $\hat{Y} = f(X_1)$. Next find the partial correlation

coefficient of $X_j (j \neq 1)$ and Y (after allowance for X_1), i.e., find the correlation between the residuals from the regression $\hat{Y} = f(X_1)$ and the residuals from another regression $X_j = f_j(X_1)$. The X_j with the highest partial correlation with Y is now selected and the process continues. As each variable is entered into the regression, the following values are examined:

1. R^2, the multiple correlation coefficient;
2. The partial F-test value for the variable most recently entered, which shows whether the variable has taken up a significant amount of variation over that removed by variables previously entered in the regression.

As soon as the partial F value related to the most recently entered variable becomes nonsignificant the process is terminated.

APPENDIX D

STATISTICAL TESTS FOR SIGNIFICANCE

Regression procedures per se may be categorized as descriptive statistics. Regression analysis is commonly performed on sample data from which the researcher is either interested in estimating population parameters from sample regression statistics or to testing statistical hypothesis about the population parameters and determining confidence limits for estimates in testing the hypothesis.

The overall test for goodness of fit of the regression equation uses statistical inference procedures to test the null hypothesis that the sample of observations being analyzed has been drawn from a population in which the multiple correlation is equal to zero. An equivalent way of stating the null hypothesis, Ho, is that the next variable to be added in a forward regression would not add significantly to the explained variance in the dependent variable, Y, already accounted for by variables included in the regression equation. The alternate hypothesis, H_1, directly contradicts the null hypothesis.

The test statistic employed for the overall test is

$$F = \frac{SS_{reg}/K}{SS_{res}/(N-K-1)} = \frac{R^2/K}{(1-R^2)/(N-K-1)}$$

where SS_{reg} is the sum of squares explained by the entire regression equation, SS_{res} is the residual (unexplained) sum of squares, K is the number of independent variables in the equation and N is the sample size. The F ratio is distributed approximately as the F distribution with degrees of freedom K and (N-K-1).

Adjusted R^2 is an R^2 statistic adjusted for the number of independent variables in the equation and the number of cases. It is a more <u>conservative</u> estimate of the percent of variance explained, especially when the sample size is small. The adjusted R^2 formula uses unbiased estimates of the error variance and the total variance of Y in the population. The formula used by SPSS is:

$$\text{Adjusted } R^2 = R^2 - \frac{(K-1)}{(N-K)} (1-R^2)$$

Becaused Adjusted R^2 is a conservative estimate of the percent of variance explained, the author used the following F statistic to determine confidence levels for the regression equations obtained for each command considered:

$$F = \frac{(\text{Adjusted } R^2)/K}{(1-\text{Adjusted } R^2)/(N-K-1)}$$

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